


High prevalence of obesity in asthmatic patients on sick leave

L. NATHELL,*^{†‡} I. JENSEN,[†] AND K. LARSSON[‡]

*The Åre Clinic, Åre, Kurortsvägen, ÅRE, Sweden, [†]Section of Personal Injury Prevention, Department of Clinical Neuroscience, Karolinska Institutet, Stockholm, Sweden and [‡]National Institute for Working Life, Respiratory Health and Climate, Stockholm, Sweden

Abstract Obesity and asthma are common chronic diseases in the industrialised world. The aim of the present study was to investigate a possible relationship between asthma and obesity among persons on sick leave due to respiratory disorder. The diagnosis of asthma ($n=237$) was made in a three-stage model (questionnaire, telephone interview and clinical examination) in persons on sick leave due to any respiratory disorder. Persons on sick leave due to non-specific spinal pain, ($n=1231$) and a general population sample ($n=5092$) were used as references. Obesity (body mass index $>30 \text{ kg/m}^2$) was found in 20.7% of the asthmatic patients on sick leave compared with 13.7% in the non-specific pain patients on sick leave and in 6.5% of the controls ($P<0.001$). It is not clear whether the increased prevalence of obesity among asthmatics reflects a true increase in asthma in obese persons or whether asthma-like symptoms occur because of obesity. Weight reduction schemes and weight maintenance programmes should be important components in treatment and rehabilitation plans for persons with asthma. © 2002 Elsevier Science Ltd. All rights reserved.

doi:10.1053/rmed.2002.1317, available online at <http://www.idealibrary.com> on 

Keywords absenteeism; asthma; body-mass index; health expenditures; obesity; respiratory symptoms.

INTRODUCTION

Asthma is one of the most common diseases and its prevalence has increased in industrialised countries during recent decades (1,2). The prevalence rate of asthma in northern Europe is 5–10% (1,3–5). Overweight and obesity is also an increasing problem in the western world (6,7). A clinical impression is that obesity is observed more often in asthma patients than in a healthy population. A number of recent studies have also indicated this association between asthma and obesity (8–15). The significance of the association of asthma and obesity has been further reinforced by several studies which demonstrate that weight loss is associated with improvement in asthma (16–19).

We have previously shown that asthma is an important diagnosis among persons on sick leave due to respiratory disorder (20). If the relationship between asthma and obesity is strong among persons on sick leave due to asthma, it will implicate that weight reduction programmes should be included in the treatment plans for overweight asthmatics in order to decrease the cost of sick leave.

The aim of the present study was to investigate a possible relationship between obesity and asthma among persons on sick leave due to respiratory disorder. If such a relationship is found, it will lead to the conclusion that weight reduction is an important component to include in treatment and rehabilitation programmes for persons with asthma.

MATERIAL AND METHODS

The diagnosis of asthma was made in a three-stage fashion. First, a questionnaire was sent to persons who had been on sick leave for more than 2 weeks due to respiratory symptoms or diagnoses. Second, a structured telephone interview was performed, and third, following the interview the patients were referred for a clinical examination.

Study population and the questionnaire

AGS is a compulsory sickness insurance paid for by the employer for 2.4 million employees in Sweden, mainly manual workers. The AGS register indicates the employee's sex, age, area of residence, employer and type of occupation, and diagnoses for sick leave periods 15 days and longer (21). All sick leaves registered in the AGS under

respiratory diagnoses from 1 January 1994 to 29 February 1996 for individuals born in 1941 or later and employed in the private sector were selected for the questionnaire study (approximately 35% of the total Swedish work force). Persons on sick leave following surgery involving the respiratory tract such as tonsillectomy, pleurectomy and surgery to correct snoring were excluded. Only persons 56 years of age or younger were chosen in order to decrease the risk of including patients with chronic obstructive pulmonary disease (COPD).

The questionnaire used in the present study was based on the validated OLIN Studies Questionnaire (22, 23). The questionnaire included questions concerning respiratory symptoms and diseases and smoking habits. Physician-diagnosed asthma, self-reported asthma, or whether any anti-asthmatic medications were being used was also reported. The answers required were either Yes or No. Two reminders were sent out to those not responding initially.

The definition of "self-reported respiratory disease" covered reports of "having or having had asthma, chronic bronchitis or emphysema", or "physician-diagnosed asthma, chronic bronchitis or emphysema" or "use of asthma medications".

The definition of "respiratory symptoms" covered "attacks of breathlessness", "long-standing cough", "productive cough", "wheezing", "troublesome colds", "exertional dyspnoea", "breathlessness, wheeze or severe cough in special circumstances".

Persons who had stopped smoking more than 12 months before the study were regarded as ex-smokers.

Structured interview

Persons living in communities, including rural and urban areas around 11 Swedish towns and cities, were selected for the structured telephone interview. All individuals in these areas who, based on the questionnaire, indicated "self-reported respiratory disease" or "respiratory symptoms" were selected for the interview. All who responded to the telephone call were included. Five attempts to call each person were made, at home as well as at work. The interview included detailed questions on wheezing, shortness of breath, chest tightness/chest pain, situations or agents provoking airway symptoms, cough and phlegm production, allergy and allergic symptoms, drug consumption and impact of symptoms on daily living (23).

The diagnoses of "asthma" and "suspected asthma" were made in accordance with the diagnostic criteria suggested by the ATS (24).

The following criteria had to be fulfilled for the diagnosis of asthma:

- -Attacks of breathlessness or periodic shortness of breath at least twice during the past year and normal breathing between the attacks.

- -Regular wheezing or wheezing along with breathlessness without a concurrent cold during the past year.
- -At least two asthma-provoking factors such as allergens, irritants, cold air or exercise.

"Suspected asthma" was defined as the reported presence of any, but not all, of the above symptoms.

Asthma was also considered to occur in those who reported having or having had asthma together with either current use of asthma medications or reported any of the above-listed symptoms.

Clinical examination

All who were classified as having "asthma" or "suspected asthma", according to the structured interview were invited to a clinical examination. Two ambulating specially trained nurses performed spirometry and a skin prick test. Spirometry was performed with a dry bellows spirometer (Vitalograph[®], Buckingham, England) according to the recommendations from the ATS (25) with a few modifications. The spirometry was performed in the sitting position and a nose clip was used. Spirometry was performed before and 15 min after inhalation of salbutamol dry powder (4×0.2 mg Ventolin[™] Rotahaler, Glaxo-Wellcome). Short acting bronchodilator medication was withheld 4 h before the reversibility testing and long acting for 12 h. European reference values were used, and the bronchodilator test was considered positive if FEV_{1.0} and/or FVC/VC increased by $\geq 12\%$ of the predicted value and at least 200 ml (26).

Instruction on how to use a Mini-Wright peak flow meter (Clement Clarke International Limited, Harlow, U.K.) and how to record peak flow data 5 times daily during a period of 2 weeks were also given at the examination. Variable airway obstruction, based on the PEF measurements, was considered to be present if any one of the following criteria was met:

- - $[(\text{highest value} - \text{lowest value}) / \text{lowest value}] > 15\%$ on 3 days out of 14
- -as above but $> 20\%$ on 2 days out of 14,
- -a difference of 25% or more between the highest and second lowest PEF values during a 7-day period,
- -a difference of 30% or more between the highest and second lowest PEF values during a 14-day period.

The skin prick test (SPT) was performed using common allergens (ALK, Hørsholm, Denmark) in Sweden (birch, timothy grass, mugwort, aspergillus, cladosporium, dermatophagoides farinae, dermatophagoides pteronyssinus, cat and dog). The SPT was performed in accordance with the manufacturer's instructions. An SPT was considered positive when the diameter was ≥ 3 mm larger than the control (allergen solvent).

Atopy was defined as the presence of at least one positive SPT reaction.

"Asthma": Those who were classified as having "suspected asthma" according to the structured interview and had either a positive bronchodilator test or variable airway obstruction were classified as having asthma together with those who were classified as having asthma, according to the structured interview, regardless of the results of the bronchodilator test and peak flow registration.

Overweight and obesity: The body mass index (BMI) was calculated using the formula [weight in kilograms/(height in meters)²]. Weight and height were self-reported. Underweight was defined as BMI <20, normal weight as 20 ≤ BMI ≤ 25, overweight as 25 < BMI ≤ 30 and obesity was defined as BMI > 30 kg/m².

Reference groups: Data on weight and height were collected for a random sample ($n=1231$) of persons, 56 years of age or younger, registered for a sick leave period in the AGS during 1997 due to non-specific pain from the lower back and/or neck. For a random sample of these, consisting of 459 persons, data on smoking habits were collected to be used in a multiple logistic regression model. Data were also obtained from the Swedish National Survey of Living Conditions as a second reference material for BMI. The surveys of living conditions are conducted in the form of interviews with a random sample of the population, usually within the age group 16–84 years. Between 12 000 and 13 000 people are interviewed over a period of 2 years. From the interviews performed in 1996–1997 a sample of 5092 interviews, consisting of persons from the same socio-economic groups and within the same age group as the study population, was chosen to serve as a second reference group.

Analysis

The data collected were analysed statistically using SPSS (Statistical Products and Service Solutions) for Windows, release 10.0.5. Group comparisons were made using the chi-square test (exact test). P -values <0.05 were considered statistically significant. The 95% confidence intervals (CI) were calculated using the binomial proportion " p " \pm 1.96 times the standard error. For the proportions " p " in the different samples of size " n ", the standard error was calculated using the formula: $\sqrt{(p(1-p)/n)}$.

A multiple logistic regression model was used among persons with asthma and persons on sick leave due to non-specific pain from the lower back and/or neck to describe the relationship between the dependent dichotomous variable obesity and the independent variables, sex, age, smoking habits and diagnosis.

RESULTS

Questionnaire

A total of 3152 persons (56.8% men) constituted the study group for the questionnaire study. The mean age was 39.7 years with no gender difference. The response rate after two reminders was 82.8%. No miscoding was found when the coding was checked in a random sample of 450 questionnaires (17%).

There were 40.5% current smokers, 21.9% ex-smokers and 37.6% non-smokers. The smoking habits were different between men and women ($P < 0.001$). Among men 35.1% were current smokers and 27.1% were ex-smokers. The corresponding figures among women were, respectively, 47.2 and 15.5%. A total of 1929 persons (73.9%) were classified as having "self-reported respiratory disease" or "respiratory symptoms" (Fig. 1).

Structured interview

Of those classified as having "self-reported respiratory disease" or "respiratory symptoms", 963 (50%) lived in the selected geographical areas. A total of 588 persons (61%) responded to the telephone calls and were included in the interview, and 558 (94%) completed the structured interview (Fig. 1). Thirty persons were not interested in participating, twelve stated that they felt completely well, nine did not give a reason, one because of a very sick child, two because of language problems, two because of other severe diseases (tuberculosis, treatment of Hodgkin's disease), and four persons were died (three due to unknown causes and one due to obstructive airways disease). Those not responding to the telephone call did not differ in age, gender or smoking habits compared to the participants. However, those not responding had a lower prevalence of self-reported asthma (30.3%) than the responders (39.5%), ($P=0.008$).

Based on the results of the interview a diagnosis of asthma was made in 277 subjects (49.6%) and 178 subjects (31.9%) were considered to have suspected asthma. A diagnosis of asthma was excluded in the remaining 103 subjects (18.5%).

Clinical examination

Persons classified as having asthma or suspected asthma according to the structured interview ($n=455$) were invited to a clinical investigation, 314 (69%) of whom participated, 191 with asthma and 123 with suspected asthma (Fig. 1). Among those not participating, 114 persons (81%) were not interested or did not show up, 12 persons (8%) had a current illness or a sick child, 8 persons (6%) could not come due to extremely bad weather and 7 persons (5%) could not come due to working conditions. There were no differences in age, gender, smoking habits or

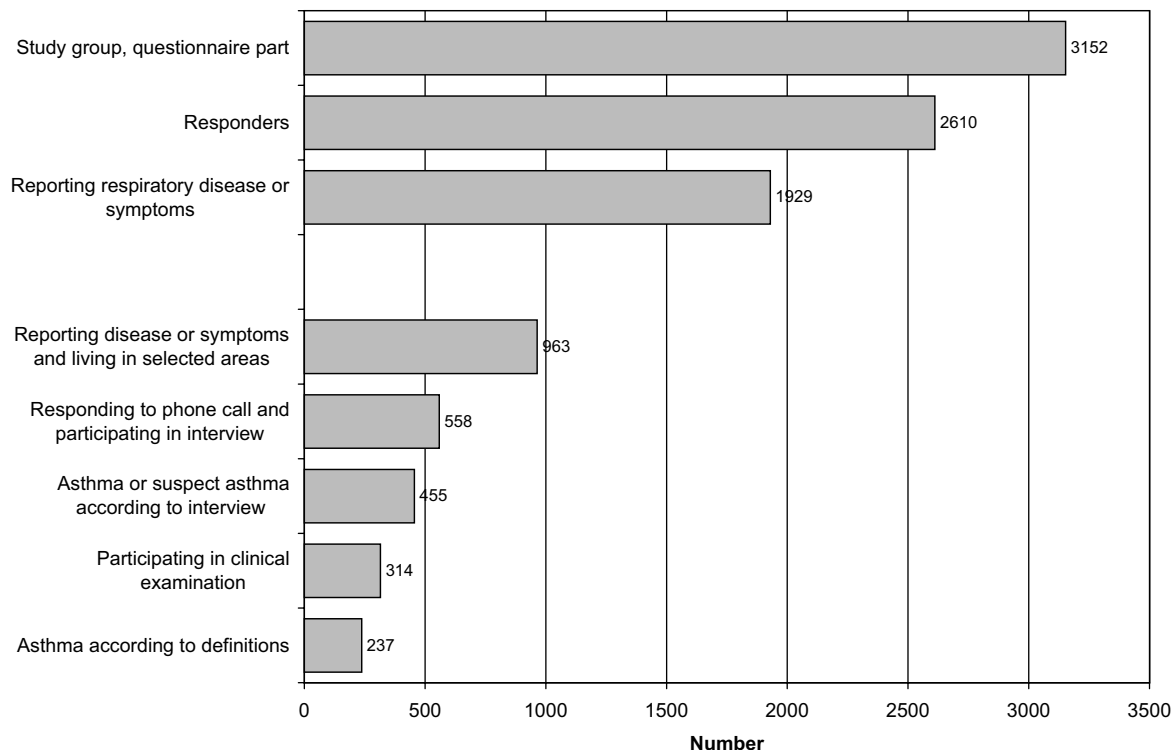


FIG. 1. Number of participants in each step of the examination process to diagnose asthma among persons on sick leave due to respiratory disorder.

the proportion coded as having asthma and suspected asthma, between those attending the clinical examination and those who did not.

Among the 123 persons with suspected asthma who participated in the clinical examination, the diagnosis was verified in 46 (37.4%). Confirmation of the diagnosis was based on PEF variability ($n=42$), a positive bronchodilator test ($n=2$) and on PEF variability along with a positive bronchodilator test ($n=2$).

The study sample is presented in Table I. The 237 asthmatic patients (137 women, 58%) were divided into four groups based on BMI: underweight, normal weight, overweight, and obese. Age, lung function and smoking habits were similar in the normal weight, overweight, and obese groups while the underweight persons reported a higher tobacco consumption, were younger and had a slightly impaired lung function compared with the other groups. Atopy was more prevalent in the overweight and obese groups compared with the underweight and normal weight groups. Atopy was more prevalent among men than among women (59% vs 43% $P=0.018$) and this pattern was seen regardless of weight group. The proportion of subjects with a previous physician diagnosed asthma and the use of corticosteroids varied slightly but not in a consistent manner between the groups (Table I).

Obesity and overweight in asthmatic patients compared with non-specific spinal pain patients and a general population sample

Obesity was more frequent in asthmatic patients (20.7, 95% CI 15.5–25.8) than in the general population sample (6.5, 95% CI 5.8–7.2) and also more frequent in asthmatic patients compared with persons on sick leave due to non-specific pain (13.7, 95% CI 11.8–15.7) ($P<0.001$) (Fig. 2). The prevalence of subjects with either obesity or overweight was the same among the asthmatic patients and persons on sick leave due to non-specific pain but higher than in the general population sample (Table 2).

The data were also analysed by multiple logistic regression among those diagnosed with asthma and those on sick leave due to non-specific spinal pain. Female gender (OR 1.69) and a diagnosis of asthma (OR 1.62) showed increased risks for obesity (Table 3).

DISCUSSION

It has been shown in the present study that obesity is substantially more prevalent in patients on sick leave due to respiratory causes with asthma than in patients

TABLE I. Number, gender, age, smoking habits, lung function, atopy, asthma diagnosis and medication for the study sample

		Group A: underweight	Group B: normal weight	Group C: overweight	Group D: obese	All
Number	All	17	94	77	49	237
	Men	5	42	37	16	100
	Women	12	52	40	33	137
Age (years)	Median (quartiles)	40.0 (32.0; 48.0)	42.5 (32.0; 50.0)	46.0 (38.5; 51)	45.0 (38.0; 51.5)	44.0 (35.8; 50.0)
BMI (kg/m ²)	Mean (SD)	18.6 (1.3)	22.8 (1.4)	27.3 (1.4)	33.7 (3.7)	26.2 (5.0)
Smoking habits	Smokers (%)	64.7	48.4	41.6	49	47.7
	Ex-smokers (%)	17.6	16.1	27.3	14.3	19.4
	Non-smokers (%)	17.6	35.5	31.2	36.7	32.9
FEV1.0 % of predicted	Mean (95% CI)	83.2 (71.3–95.1)	95.9 (92.2–99.7)	93.7 (88.9–98.5)	94.1 (89.3–99.0)	94.0 (91.4–96.5)
FEV1.0/VC × 100	Mean (95% CI)	71.6 (62.7–80.4)	76.1 (74.0–78.1)	76.0 (73.5–78.5)	77.8 (75.1–80.4)	76.0 (74.6–77.5)
Atopy	%	47.1	43.6	54.5	55.1	50.0
Asthma previously diagnosed by a physician	%	58.8	45.7	57.1	63.3	54.0
Use of inhaled steroids during last year	%	64.7	46.8	53.2	61.2	53.2
Use of oral steroids during last year	%	29.4	12.8	23.4	20.4	19.0

on sick leave due to non-specific pain or than in a general population. Improvements in various asthma severity variables after weight reduction in obese asthmatic patients has been demonstrated in recent studies (17,18,19). In order to reduce the number of sick leave days and prevent persons with asthma and obesity from going on pension, attention needs to be focused on weight reduction and weight maintenance programmes.

Although smokers were included in the present study, we have strong reasons to believe that most of the patients suffered from asthma and not from COPD. First of all, the diagnosis was based on a number of questions in a validated questionnaire (23) and the diagnosis of asthma was regarded as positive when the answers met the ATS criteria for asthma. Second, in cases that did not completely meet the ATS criteria for asthma, the diagnosis was confirmed by PEF variability or a positive bronchodilator test according to the recommendations of the European Respiratory Society. Third, only persons under 56 years of age were included. Fourth, the smoking habits were similar in normal, overweight and obese patients, which implies that any COPD patients who may have been included in the study are probably evenly distributed between the three groups. Subsequently, subgroup analyses of only "never-smokers" or groups from which smokers with different degrees of lung function impairment were excluded did not change the results or the conclusions drawn from analyses of the whole material. Further, lung function is not significantly different on comparing smokers with non-smokers, indicating that smoking has not induced COPD in these patients.

However, the prevalence of smokers among the asthmatics is very high. The prevalence of daily smokers among a general population sample in Sweden during 1995 was between 20 and 30% in the age groups that were included in the present study. In another study of persons on sick leave the prevalence of smokers among persons (mean age 42 and 62% males) on sick leave due to a non-respiratory cause was 37% (20). Hence, we see a pattern where persons on sick leave are smokers to a greater extent than the general population and persons on sick leave due to respiratory causes are smokers to a greater extent than persons on sick leave due to non-respiratory causes. And among those on sick leave due to respiratory causes, who have asthma according to our definition, the prevalence of smokers is 47.7% as reported in the present study.

The body mass index in the present study was calculated using self-reported weights and heights. A systematic tendency for overweighted and obese subjects to underestimate their body size has been reported in a Swedish study (27). A similar underestimation of obesity would be expected in the present study. But persons with asthma and on corticosteroid medications and persons giving up regular exercise due to breathlessness may feel happier to give an accurate assessment of their body weight. However, the possible underestimation in non-asthmatics could not have changed the main results significantly.

The diagnosis of asthma in this study was made in a three-stage fashion. Using this study design, a representative sample of asthmatics from a population on sick

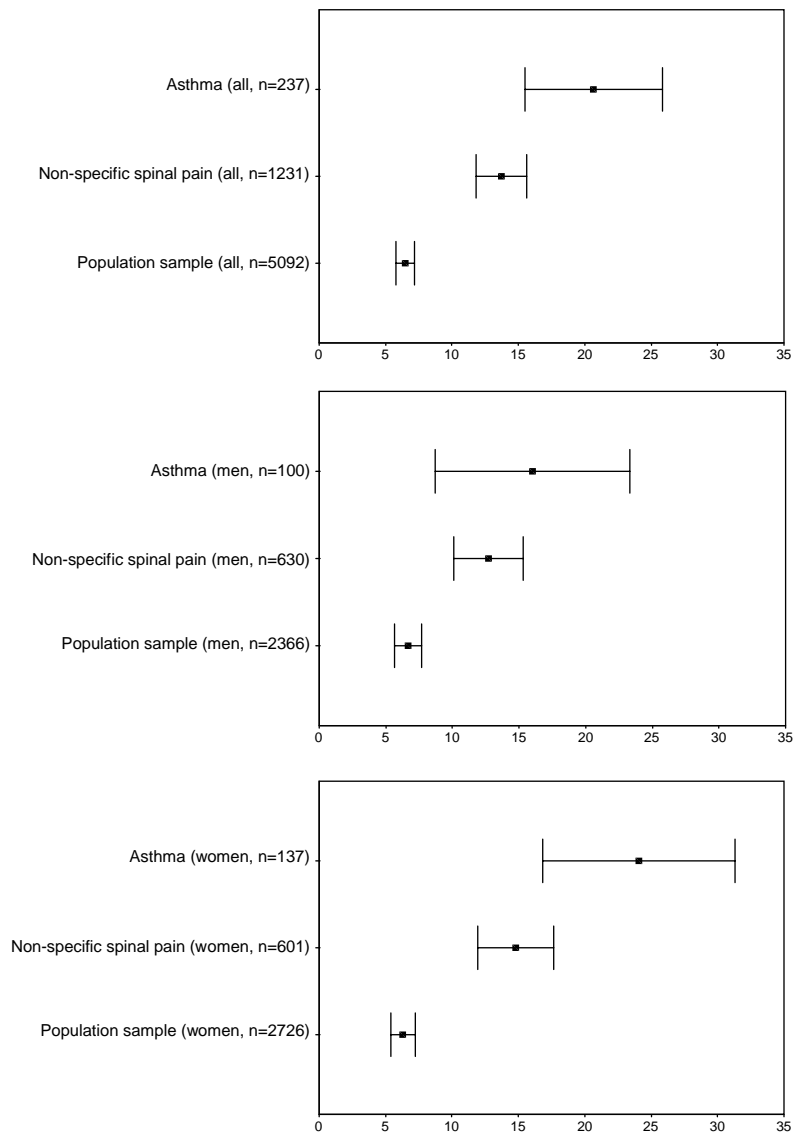


FIG. 2. Proportion (in %) of obesity, with 95% confidence intervals, among persons on sick leave with asthma, on sick leave due to non-specific spinal pain and among a general population sample, totals and for men and women.

TABLE 2. Proportions (in %) of underweight, normal weight, overweight and obese persons among persons with asthma, persons on sick leave due to non-specific spinal pain and in a general population sample.

	Underweight	Normal weight	Overweight	Obese
Asthma (n=237)	7.2	39.7	32.5	20.7
Non-specific spinal pain (n=1231)	3.5	42.6	40.2	13.7
Population sample (n=5092)	7.0	53.7	32.8	6.5

leave due to respiratory symptoms is obtained. A weakness of this design is that some subjects, for various reasons, are lost in each step. However, if all persons who were not included in the telephone interview were as-

sumed to have the same prevalence of asthma as those who participated in both the telephone interview and the clinical examination, but were all of normal weight, there would still be significantly more obese persons in

TABLE 3. Multiple logistic regression model with gender, age, smoking and diagnosis as independent variables

Independent variable:	Dependent variable:	
	Obesity OR*	(95% CI**)
All with asthma (n=237) and a sample of those with non-specific spinal pain included in the equation (n=459)		
Sex (female)	1.69	(1.10–2.59)
Age (year)	1.01	(0.99–1.03)
Smoking habits		
Non-smoker	1.00	
Current smoker	0.87	(0.50–1.50)
Ex-smoker	0.77	(0.48–1.24)
Diagnosis		
Non-specific spinal pain	1.00	
Asthma	1.62	(1.07–2.45)

*OR=odds ratio; **95% CI=95% confidence interval

the asthma group than among the general population controls ($P=0.004$). Hence, we have no reason to believe that dropouts have influenced the results.

Gennuso *et al.* concluded that asthma is a risk factor for obesity in children and adolescents (14). The reason for this would probably be a limited exercise tolerance, leading to a sedentary lifestyle and increased time indoors, with the latter resulting in an increased exposure to indoor allergens. Among adults, corticosteroid medications and smoking cessation may also increase weight. In the present study, however, no relation was found between corticosteroid medication and obesity. This is in accordance with a recent Swedish study of subjects on asthma medication in which no evidence was found that modern pharmacological asthma treatment contributes to the development of obesity (28). However, it may also be the other way around, obesity may be a risk factor for asthma, or at least asthma-like symptoms. Schachter *et al.* concluded in their study that obese persons reported more wheeze and shortness of breath but their airway hyperresponsiveness, and airway obstruction did not support the suggestion of a higher prevalence of asthma (9). Surgery for morbid obesity has recently been shown to improve asthma symptoms (27,32) and a supervised weight reduction programme for obese patients with asthma resulted in improved lung function, asthma symptoms, morbidity and health status (17,18), indicating that obesity is an important factor for asthma symptom severity. These findings may lead to the assumption that asthma is overdiagnosed in patients with overweight. The third explanation is that obesity and asthma have a common primary factor, for instance hormonal or genetic, which might explain the gender differences observed in the present study and in previous studies (11–14). Other types of confirmation of the asthma

diagnosis would be of interest in obese patients, but we are not aware of any studies in which the diagnosis of asthma has been evaluated using morphological or cellular indices in obese patients.

The present findings indicate a clear relationship between asthma and obesity and inasmuch as the prevalence of both asthma and obesity has been increasing during recent decades a causal relationship between the two conditions cannot be ruled out. The increased prevalence of obesity in the industrialised world (6–7) may thus, to some extent, be an aetiological factor in the increased prevalence of asthma as suggested by Camargo *et al.* (8). In that study, a relationship between the incidence of asthma and an increased body mass index was found in nurses who were followed prospectively for 4 years. The relative risk for the development of asthma, defined as participant-reported physician-diagnosed asthma along with the use of preventive asthma medication during the past year, was 3.0 for subjects with a BMI > 30.0, compared with the references ($20.0 < \text{BMI} < 22.4$, corresponding to RR 1.0). They concluded that obesity is a risk factor for the development of asthma and may be one of the reasons for the increase in asthma prevalence. In the present study, obesity may be an important factor for the high prevalence of asthma, thus supporting the previous suggestion, because one out of four women and one out of six men with asthma were obese (BMI > 30). However, the population studied is a highly defined one and therefore one should be careful to extrapolate these data to the general population.

Because of the strong relationship between asthma and obesity, weight reduction programmes for the obese and weight maintenance schemes for all persons with asthma should be important non-pharmacological components in modern asthma treatment. This is especially

important for persons with asthma on sick leave, since they tend to have long sick leave periods (20) leading to serious health economic consequences. No weight reduction or weight maintenance recommendations exist in current asthma management plans (31).

In our study we also showed that obesity is more common among persons on sick leave due to non-specific spinal pain, than in a general population sample. It is known that obese subjects have a higher number of sick leave days compared to normal weight subjects (32–34). Obesity may be an independent risk factor for sick leave but obese subjects could also have various co-morbidities or social factors that increase the risk for sick leave. However, in our study we have shown with the multiple logistic regression model based on data for persons on sick leave, that an asthma diagnosis is a strong predictor for obesity.

In conclusion, we have shown that obesity is more common among persons on sick leave due to respiratory causes with asthma than among persons on sick leave due to non-specific spinal pain and a general population sample. Weight reduction schemes and weight maintenance programmes are therefore important components in treatment and rehabilitation plans for persons with asthma and obesity. It is not clear whether there is a true increase in asthma in obese persons or whether symptoms similar to those of asthma occur because of obesity. This needs to be elucidated in future studies focused on the occurrence of inflammatory changes in the airways of obese and non-obese subjects with symptoms of asthma.

Acknowledgements

Financial support for this study was received from the research department of AFA (former AMF) insurance company and is hereby gratefully acknowledged. We thank professor Åke Nygren of the Karolinska Institutet for his valuable advice and support. We thank Madelene Nathell, Birgitta Lundgren, Marie Zetterberg-Bengtsson and Anna-Greta Sjödin of the Åre Asthma Clinic for their work in interviewing and examining the study subjects. We also thank professor Lennart Bodin, Örebro, for statistical advice.

REFERENCES

1. Lundback B. Epidemiology of rhinitis and asthma. *Clin Exp Allergy* 1998; **28** (Suppl 2): 3–10.
2. Burney P. Epidemiology of asthma. *Allergy* 1993; **48**: 17–21.
3. Pallasaho P, Lundback B, Läspä S, Jonsson E, Kotaniemi J, Laitinen LA. Increasing prevalence of asthma but not of chronic bronchitis in Finland? Report from the FinEsS-Helsinki study. *Respir Med* 1999; **93**: 798–809.
4. Larsson L, Boethius G, Uddenfeldt M. Differences in utilisation of asthma drugs between two neighbouring Swedish provinces: relation to prevalence of obstructive airway disease. *Thorax* 1994; **49**: 41–49.
5. Montnemy P, Adelroth E, Heuman K, Johansson A, Johansson SA, Lindholm LH, *et al.* Prevalence of obstructive lung diseases and respiratory symptoms in southern Sweden. *Respir Med* 1998; **92**: 1337–1345.
6. Seidell JC. Obesity: a growing problem. *Acta Paediatrica* 1999; **428** (Suppl. **88**): 46–50.
7. Khan LK, Bowman BA. Obesity: a major global public health problem. *Ann Rev Nutr* 1999; **19**: xiii–xvii.
8. Camargo Jr. CA, Weiss ST, Zhang S, Willett WC, Speizer FE. Prospective study of body mass index, weight change, and risk of adult-onset asthma in women. *Arch Intern Med* 1999; **159**: 2582–2588.
9. Schachter LM, Salome CM, Peat JK, Woolcock AJ. Obesity is a risk for asthma and wheeze but not airway hyperresponsiveness. *Thorax* 2001; **56**: 4–8.
10. Brown WJ, Mishra G, Kenardy J, Dobson A. Relationships between body mass index and well-being in young Australian women. *Int J Obes Relat Metab Disord* 2000; **24**: 1360–1368.
11. Castro-Rodriguez JA, Holberg CJ, Morgan WJ, Wright AL, Martinez FD. Increased incidence of asthmalike symptoms in girls who become overweight or obese during the school years. *Am J Respir Crit Care Med* 2001; **163**: 1344–1349.
12. Chen Y, Dales R, Krewski D, Breithaupt K. Increased effects of smoking and obesity on asthma among female Canadians: the national population health survey, 1994–1995. *Am J Epidemiol* 1999; **150**: 255–262.
13. Shaheen SO, Sterne JA, Montgomery SM, Azima H. Birth weight, body mass index and asthma in young adults. *Thorax* 1999; **54**: 396–402.
14. Gennuso J, Epstein LH, Paluch RA, Cerny F. The relationship between asthma and obesity in urban minority children and adolescents. *Arch Ped Adoles Med* 1998; **152**: 1197–1200.
15. Young SY, Gunzenhauser JD, Malone KE, McTiernan A. Body mass index and asthma in the military population of the northwestern United States. *Arch Intern Med* 2001; **161**: 1605–1611.
16. Brolin RE. Results of obesity surgery. *Gastroenterol Clin North America* 1987; **16**: 317–338.
17. Hakala K, Stenius-Aarniala B, Sovijärvi A. Effects of weight loss on peak flow variability, airways obstruction, and lung volumes in obese patients with asthma. *Chest* 2000; **118**: 1315–1321.
18. Stenius-Aarniala B, Poussa T, Kvarnstrom J, Gronlund EL, Ylikahri M, Mustajoki P. Immediate and long term effects of weight reduction in obese people with asthma: randomised controlled study. *BMJ* 2000; **320**: 827–832.
19. Dixon JB, Chapman L, O'Brien P. Marked improvement in asthma after Lap-Band surgery for morbid obesity. *Obes Surg* 1999; **9**: 385–389.
20. Nathell L, Malmberg P, Lundback B, Nygren A. Is asthma underestimated as a cause of sick leave? *Respir Med* 2000; **94**: 977–982.
21. Nathell L, Malmberg P, Lundback B, Nygren Å. Impact of occupation on respiratory disease. *Scand J Work Environ Health* 2000; **26**: 382–389.
22. Lundback B, Nyström L, Rosenhall L, Stjernberg N. Obstructive lung disease in northern Sweden: respiratory symptoms assessed in a postal survey. *Eur Respir J* 1991; **4**: 257–266.
23. Lundback B, Stjernberg N, Nyström L, Lundback K, Lindström M, Rosenhall L. An interview study to estimate prevalence of asthma and chronic bronchitis. The Obstructive Lung Disease in Northern Sweden Study. *Eur J Epidemiol* 1993; **9**: 123–133.
24. American Thoracic Society. Standards for the diagnosis and care of patients with chronic obstructive pulmonary disease (COPD) and asthma. *Am Rev Respir Dis* 1987; **136**: 225–244.
25. American Thoracic Society. Standardization of spirometry—1987 update. *Am Rev Respir Dis* 1987; **136**: 1285–1298.

26. Quanjer PH, Tammeling GJ, Cotes JE, Pedersen OF, Peslin R, Yernault JC. Lung volumes and forced ventilatory flows. Report Working Party Standardization of Lung Function Tests, European Community for Steel and Coal. Official Statement of the European Respiratory Society. *Eur Respir J Suppl* 1993; **16**: 5–40.
27. Kuskowska-Wolk A, Karlsson P, Stolt M, Rossner S. The predictive validity of body mass index based on self-reported weight and height. *Int J Obes* 1989; **13**: 441–453.
28. Hedberg A, Rossner S. Body weight characteristics of subjects on asthma medication. *Int J Obes Relat Metab Disord* 2000; **24**: 1217–1225.
29. Dhabuwala A, Cannan RJ, Stubbs RS. Improvement in co-morbidities following weight loss from gastric bypass surgery. *Obes Surg* 2000; **10**: 428–435.
30. Seidell JC, Flegal KM. Assessing obesity: classification and epidemiology. *Br Med Bull* 1997; **53**: 238–252.
31. National Heart Lung and Blood Institute NIOH. Global initiative for asthma, Global Strategy for Asthma Management and Prevention, NHLBI/WHO Workshop Report (March 1993). 95-3659, 1995, Ref Type: Report.
32. Burton WN, Chen CY, Schultz AB, Edington DW. The costs of body mass index levels in an employed population. *Stat Bull Metrop Insur Co* 1999; **80**: 8–14.
33. Narbro K, Jonsson E, Larsson B, Waaler H, Wedel H, Sjostrom L. Economic consequences of sick-leave and early retirement in obese Swedish women. *Int J Obes Relat Metab Disord* 1996; **20**: 895–903.
34. Seidell JC. Societal and personal costs of obesity. *Exp Clin Endocrinol Diab* 1998; **106** (Suppl 2): 7–9.